

Maryland Sea Grant College

Performance Review Panel Report for 2010-2013



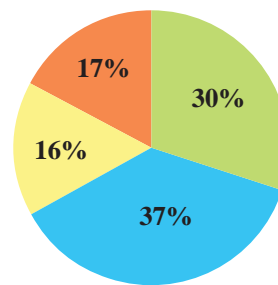
Program Introduction

Since 1977 Maryland Sea Grant has played a vital role in supporting science that informs efforts to conserve and restore Chesapeake Bay and our state's coastal resources. In this report we summarize an exciting set of successes from 2010 to 2013 that resulted from Maryland Sea Grant's innovative efforts in research, education, extension, and public outreach. Our programming is helping to solve our state's marine, coastal, and watershed environmental challenges and to improve the health and prosperity of our state's residents.

Our focus on Chesapeake Bay reflects its place as America's largest estuary and an iconic national environmental resource, one that looms large in the economy, history, and culture of our state. Our program has been at the forefront of supporting research to understand the bay's degradation during the past three decades. Anthropogenic sources of nutrients and sediments have contributed to eutrophication and to declines in Maryland's traditional fisheries for crab, oyster, and striped bass.

Maryland Sea Grant's successes in 2010-2013 stemmed from our effective strategic planning and partnerships. We teamed with 242 government agencies, nonprofit organizations, and other groups working to restore Chesapeake Bay. Within this large network, we played a unique role and made a difference because of the distinctive ways in which we funded relevant research, targeted our staff and financial resources, and worked to translate research into outreach and actionable science. As a result, we exceeded almost all of our plan's Program Performance Measures for 2010-2013.

To support research relevant to restoring and sustaining Maryland's Chesapeake and coastal bays, we worked with our partners to identify



Funding by Focus Area 2010-2013

- Resilient Ecosystem Processes and Responses
- Sustainable Natural Resources of Coastal Maryland
- Understanding Regional Effects of Climate Change and Sea Level Rise and Their Impacts on Coastal Communities and Ecosystems
- Viable Coastal Communities and Economies

key gaps in scientific understanding of the bays' ecosystems. We supported groundbreaking, interdisciplinary research that addressed critical issues including the interaction of multiple stressors on ecosystem functions. We synthesized research findings in areas like ecosystem-based fisheries management and aquatic invasive species to provide natural resource managers and other audiences with tools and information relevant to adaptive management and science-based approaches to restoration.

We tightly integrated these research activities with innovative and robust activities in other parts of our program. For example, we augmented the research we funded on eutrophication by hiring five new Extension specialists to help lead local watershed restoration projects to improve water quality. These efforts supported the installation of 411,500 square feet of stormwater control measures valued at \$3.7-million. We coupled research with education by funding 27 graduate fellows in environmental science and federal policy and educating more than 70 undergraduates in a summer Research Experiences for Undergraduates program. Our magazine *Chesapeake Quarterly* explained environmental science to 40,000 print subscribers and online readers annually.

Maryland Sea Grant is proud of its unique impacts and accomplishments from 2010 to 2013.

24

Research Projects

202

College Students

95

Journal Articles

869

Jobs

\$40,000,000

in Impacts

Sustainable Natural Resources of Coastal Maryland

Safe and Sustainable Seafood Supply

Maryland Sea Grant Performance Review Panel Summary Report

Maryland Sea Grant's Fisheries and Aquaculture Goals

- Improve the scientific foundations for managing, conserving, and restoring natural resources
- Develop technologies needed for restoration, aquaculture, and marine products
- Implement adoption of ecosystem-based fisheries management in Chesapeake Bay
- Inform consumers who understand the importance of ecosystem health and sustainable harvesting practices to the future of our domestic fisheries, who appreciate the health benefits of seafood consumption, and who understand how to evaluate the safety of the seafood products they buy

In its research and extension work Maryland Sea Grant (MDSG) is continuing its long-standing focus on achieving sustainable harvests for the traditional, beleaguered fisheries of Chesapeake Bay and on supporting the newly reborn and rapidly expanding aquaculture industry. Those occupations produce healthy seafood for the state's citizens, shape the culture of tidewater Maryland, and create thousands of jobs for watermen and for seafood handlers, processors and truckers. According to estimates from the Maryland Department of Natural Resources, Maryland's seafood industry annually adds approximately \$600-million to the state's economy.

Among the challenges facing this industry are declines in traditional fisheries for oysters and blue crabs. When overfishing and disease reduced Chesapeake Bay's oyster population to one percent of its historic levels, fishing pressure increased for blue crabs, helping reduce population levels for this species as well. MDSG responded to these challenges by directing major research and extension efforts in 2010-2013 focused on clarifying the recruitment pathways for blue crabs and striped bass, rebuilding oyster populations, developing workable aquaculture options, and training new oyster growers in these techniques. Research pays off when it shapes management, so we have also supported research and communication efforts designed to advance the use of ecosystem-based fisheries management in Chesapeake Bay.

MDSG's advisory work and MDSG-funded research findings played important roles in a series of historic decisions about blue crabs, oysters, and finfish. In 2008 state agencies in Maryland and Virginia put aside historical conflicts to jointly enforce cutbacks on the harvesting of female crabs. In 2010 the state of Maryland finally decided to encourage and promote oyster aquaculture, a decision resulting from an Oyster Advisory Commission staffed by an MDSG Extension specialist who provided technical and historical background for the decision. And in 2011, the Atlantic States Marine Fisheries Commission took an important step towards ecosystem-based fisheries management by voting for more restrictive caps on the commercial harvesting of menhaden.

Key Impacts, 2010-2013

- Trained 27 new oyster growers who produced 523 million spat on shell valued at \$7.8-million.
- Raised hatchery production of oyster spat to a record 1.2 billion in 2013.
- Enlisted 20 businesses in a Crabmeat Quality Assurance Program, helping increase revenues by \$17.6-million.
- Created a method for flash-freezing crabmeat, helping increase processors' revenues by \$6.3-million and supporting 168 jobs.
- Designed a buyback to retire unused crab licenses, saving Maryland \$750,000.
- Identified a disease organism commonly found in dead crabs in shedding operations.

Building a Sustainable Blue Crab Fishery

Blue crabs are now the most important fishery in Maryland's Chesapeake Bay with 18.7 million pounds harvested in 2013, a catch that produced \$50-million in dockside sales and generated nearly \$150-million in total economic activity in the state. The crab fishery that year totaled five times the dockside value of striped bass and seven times the value of oysters. That 2013 harvest, however, represented a 41 percent drop from the previous year.

• **Research to support managing the blue crab population.** To support management of this valuable but volatile fishery, MDSG-funded research has helped create **a more detailed explanation of population dynamics** that explained these unexpected drops and jumps in blue crab numbers. Our previous long-term regional research collaborations with the Delaware and Virginia Sea Grant programs documented variation in the offshore-onshore odyssey of blue crab larvae, a critical life-stage that affects recruitment to future year classes.

Those findings left tough questions about how to manage a fishery with such erratic recruitment patterns. To help decisions by resource managers, our recent research projects have focused on identifying nurseries in Chesapeake Bay that are so important for those crabs that manage to return to the Chesapeake. MDSG-funded researchers from the Smithsonian Environmental Research Center (SERC) surveyed nursery grounds, identified key areas offering blue crabs good survival potential, and estimated their crab-carrying capacity using statistical models and geospatial analysis focused on the key characteristics of quality habitats for juvenile blue crabs. The researchers found that a low number of juveniles were entering these habitats.

Management outcomes: These findings **strongly support management policies** adopted by Maryland and Virginia that reduced the harvest of female crabs as a key step to rebuild blue crab populations.

• **Buying crab fishing licenses.** Managing the blue crab fishery has also been complicated by sociological factors, and one of them is the existence of long-standing but rarely used crab fishing licenses. In 2007, for example, fewer

than half the license holders reported blue crab catches and sales. The management concern is that a rebound in blue crab populations could lead to a spurt of unexpected – and unpredicted – fishing activity by holders of these unused licenses. MDSG Extension did an economic analysis and designed a program for the Maryland Department of Natural Resources (DNR) to buy back (retire) licenses using a reverse auction approach. The agency saved so much money repurchasing Limited Crab Fishing Licenses that it was able to organize a second buyback focused on Tidal Fishing Licenses.

Management outcomes: DNR retired 683 limited licenses and 100 full fishing licenses at a savings of \$750,000. As a result, **DNR is now able to predict fishing activity more accurately**, a key step in managing for a sustainable fishery.

• **Studying a deadly crab virus.** In 2013 MDSG-funded researchers from the University of Maryland Center for Environmental Sciences (UMCES) and SERC responded to a disease outbreak threatening fishing operations focused on soft-shell and peeler crabs, a small but slowly growing part of the blue crab fishery. It is profitable but labor-intensive work in which operators allow crabs to molt in shedding facilities placed in the water, on docks, or in land-based systems using recirculating water.

When Maryland crabbers began reporting dieoffs of 25 percent or more of their catch during the shedding process, researchers investigated dead and dying peeler crabs from shedding stations and live crabs from nearby Chesapeake Bay waters. The UMCES team used reverse transcript PCR (polymerase chain reaction) to develop a fast quantitative assay that could be used to analyze dead crab tissue.

With this new tool they were able confirm that more than 50 percent of the dead crabs were infected with a reo-like virus (RLV) that is specific to crabs.

Management outcomes: This research has **important implications for fishery management policies**. The work showed that viral outbreaks can vary widely in intensity, duration and

location, and it documented the common but questionable practice in which many watermen dispose of their dead crabs in fishing waters, a practice that could increase viral presence in these waters. The research team has communicated these findings both to fisheries managers with the Maryland DNR and to crabbers through the outreach efforts of MDSG Extension.

Protecting and Promoting Blue Crab Products

Maintaining the state's reputation for healthy, disease-free blue crab products is especially important to an industry that now faces competition from imported crab products and has seen half the state's crabmeat processors go out of business over the last 15 years. To support this traditional industry, Maryland Sea Grant Extension has participated in an array of programs and trainings to help local processors to develop and market new seafood products for regional consumers.

• **Developing new products.** To expand the market for local blue crab products, our Seafood Technology Specialist partnered with the Chesapeake Seafood Industries Association to develop a **new method of preserving crabmeat** through cryogenic freezing. This technology was adopted as an alternative to pasteurization, which, according to surveys, produces a flavor that some consumers dislike.

Commercial outcomes: With guidance from our specialist, six Maryland processors adopted cryogenic freezing techniques. Economic analyses suggest that these investments earned participating companies **\$6.3-million in increased revenues**. They also **created 168 jobs and retained 250 jobs** during 2011 alone.

• **Promoting seafood safety.** MDSG Extension has led efforts to train local processors in techniques for preventing foodborne illnesses and building trust among its customers. These efforts included a voluntary program called the Maryland Crabmeat Quality Assurance

Program and continual training in Hazard Analysis and Critical Control Point (HACCP). In our program, businesses agree to undergo food safety inspections that go beyond what is required by state and federal laws. In return, the businesses may print a specially designed logo on their products. From 2010 to 2013, a large portion of the state's crabmeat processors participated in the program – 20 businesses in all that employed 146 workers.

Commercial outcomes: Economic estimates suggest that participating companies **increased their revenues by 15 to 20 percent**. Those added revenues totaled **\$17.6-million between 2010 and 2013** and helped to retain those businesses and **146 jobs** in Maryland.

Number of seafood businesses that adopt responsible harvesting and processing techniques.

Expected **3** Actual **1,023**

Rebuilding Oyster Populations

Complicating the job of fisheries management in Chesapeake Bay is the fact that all the major fisheries are interconnected – the crash in oyster populations accelerated overfishing of blue crabs. That's why restoring oyster populations, expanding oyster aquaculture opportunities, and rebuilding blue crab populations are key interconnected tasks where Sea Grant research and extension have played critically important roles.

- **Growing oyster spat-on-shell.** Maryland Sea Grant has directly supported efforts by the state of Maryland to restore the bay’s historic oyster reefs and to expand oyster aquaculture. The major source for oyster spat-on-shell used both in reef restoration and in aquaculture has been the Horn Point Oyster Hatchery managed by Don Meritt, a Maryland Sea Grant Extension Specialist. From 2010 to 2013, the hatchery **increased its production of spat** from 556 million to 1.2 billion.

Where could all this spat on shell have the greatest impact on rebuilding or recreating natural oyster reefs in Chesapeake Bay? MDSG funded researchers from UMCES, East Carolina University, and Maryland’s DNR who integrated historical data and statistically derived relationships to create **a model that managers are using** to make predictions about where to place shell and spat-on-shell in order to take best advantage of natural spatfall patterns under upcoming weather conditions. Results to date indicate the model can predict regions of higher juvenile abundance several months in

advance.

Management outcomes: The research findings provided evidence that supports the decision by the U.S. Army Corps of Engineers to locate a major, multi-year oyster restoration project in Harris Creek, a tributary of the Choptank River in Maryland. This project will serve as an important test case of oyster restoration methods in Chesapeake Bay generally. These findings were reported in the *Journal of Shellfish Research*.

- **A television documentary to educate the public.** To build better public understanding of the tricky issues facing the traditional Chesapeake Bay oyster fishery and the new aquaculture potential, MDSG filmed and produced a 58-minute television documentary that reached a large audience. “Who Killed *Crassostrea virginica*: The Fall and Rise of Chesapeake Bay Oysters” was broadcast on public television stations 90 times between 2011 and 2014, reaching audiences in 29 television markets in 16 states.

Creating Aquaculture Opportunities

In 2010 the state of Maryland announced a new legal framework for aquaculture, opened up new areas for leasing, and began a number of programs to encourage and support new private investments in oyster farming. The new approach grew out of work by the governor’s Oyster Advisory Commission that was staffed in part and advised in depth by Maryland Sea Grant Extension Agent Don Webster. His work helped provide the historical and technical foundation for the commission’s recommendations.

The new policy opened 600,000 acres of Chesapeake Bay’s bottom to new leases. New, would-be oyster farmers began to respond. As of 2013, the Maryland Department of Natural Resources (DNR) — with ongoing guidance and on-the-ground training from our Extension specialists — had issued more than 300 aquaculture leases covering more than 3,500 acres of the estuary.

- **Helping aquaculture operators obtain financing.** One of the biggest roadblocks to launching new aquaculture businesses is the sizable upfront investment required. Since 2011, Maryland oyster growers have been able to apply to the Maryland Agricultural and Resource-Based Industry Development Corporation (MARBIDCO) to receive low-interest loans to launch their operations. MDSG supports this loan program through the work of an

Extension Aquaculture Business Specialist who helps applicants develop their business plans.

Commercial outcomes: Between 2011 and 2013, **the specialist provided guidance on**

Tools or guidelines derived from research to improve seafood production, quality, and processing.

Expected  **2**

Actual  **18**

43 loan applications that were approved by MARBIDCO, resulting in \$2.5-million in loan commitments. These loan commitments helped create **48 businesses and 98 jobs.**

• **Providing oyster seed and training for aquaculture.** To support this new push to expand oyster aquaculture industry, MDSG helped provide both seed oysters and training for new oyster farmers. The Horn Point Oyster Hatchery managed by our Extension Specialist sold **\$113,000 worth of oyster shell** to aquaculture operators in 2013 and **donated \$156,000 worth of spat** to growers.

Extension Agent Don Webster began directing a Remote Setting Training program (RST) in 2011 to teach new growers the techniques for setting hatchery-grown larvae on oyster shell placed in tanks maintained at different locations around the state. The program was funded by the Maryland DNR and developed with the Maryland Oyster Recovery Partnership.

Commercial outcomes: By 2013, 27 growers were participating in the program and RST was operating 31 setting tanks at nine locations, renting them out for two-week periods to new growers. Between 2011 and 2013, participants produced a total of **523 million spat-on-shell valued at \$7.8-million** for use in their aquaculture leases. This program helped create **21**

Revealing Recruitment Patterns for Key Finfish Species

Chesapeake Bay provides habitats not only for shellfish but also finfish, including species that spawn in coastal waters above the continental shelf and make their way into the bay for part of their life cycle. Maryland Sea Grant collaborated in a regional research study with Sea Grant programs in Delaware and Virginia to clarify understanding of the recruitment of coastal spawning fish, such as menhaden, into Chesapeake and Delaware Bays. The researchers found that larvae coming into the Chesapeake Bay vary hugely in age, growth, and feeding patterns from year to year with nine-fold variations in abundance. Outcomes: Based on this extensive fieldwork, the research-

businesses and 51 jobs.

• **Minimizing effects of oyster waste.** As aquaculture operations increase in size and number, there is rising concern about how these facilities might affect local water quality or increase eutrophication. To explore these issues, MDSG funded UMCES scientists who collaborated with a major oyster growing company to quantify the deposition, resuspension, and dispersal of oyster feces, pseudofeces, and nutrients from floats used in off-bottom oyster and mussel aquaculture. Outcome: The researchers identified important estuarine dynamics that industry and management need to consider in order to minimize environmental impacts when siting new aquaculture operations.

To explore another approach for maintaining water quality near oyster facilities in Chesapeake Bay, MDSG funded novel research to develop an innovative system for growing macroalgae adjacent to aquaculture floats.

Outcomes: The result was a **value-added product** that can both take up excess nutrients and produce a harvestable high-value crop in addition to oysters. After evaluating four seaweed species, researchers identified *Gracilaria vermiculophylla* as a preferred species to grow for removing nutrients. The researchers also teamed up with industry to explore use of these algae as feedstock.

ers **developed models of larval ingress to inform resource management** planning and monitoring.

Another major research advance in understanding the dynamics of fishery populations came from a MDSG project designed to investigate the importance of diversity in the ages of female fish in each successful spawning class and to clarify the role played by biodiversity in fish populations in promoting population resiliency. Researchers from the UMCES Chesapeake Biological Laboratory and the Institute of Marine and Environmental Technology classified striped bass into two groups: residents who

remained in freshwater habitats and migrants who moved down estuary during their juvenile stages. Outcomes: The researchers' findings not only provided important insights for fishery

managers, they were published in the *Journal of Fish Biology*, and their report in the *North American Journal of Fisheries Management* was chosen best paper of the year for 2014.

Rethinking Fisheries Management

Maryland Sea Grant has been advancing the cause of ecosystem-based fisheries management (EBFM) since 2008 when we launched a major, multi-year project. The goal was to quantify and model the ecological and economic interactions that affect the sustainability of commercially important fish species like striped bass and menhaden in an ecosystem as complex as Chesapeake Bay. Project scientists analyzed existing literature on EBFM and created synthesis statements designed to guide future research on key species and to clarify the management adaptations that this approach might require.

Management outcomes: This work was provided to the Atlantic States Marine Fisheries Commission, which in 2011 **decided to decrease commercial harvests of menhaden** in hopes of increasing the spawning stock of this important species. The decision recognized the economic value of the menhaden harvest and the ecosystem services they provide, for example, as a food source for other species. The EBFM framework developed by MDSG also influenced the decision by EPA's Chesapeake Bay Program to establish a Sustainable Fisheries Goal Implementation Team and to include EBFM as a key part of its management tool kit.

• **Coupled economic and ecological models for EBFM.** In recent years MDSG has addressed a perceived weakness in the EBFM approach: the need to integrate economic impacts and interactions into management decision making. MDSG funded researchers from the University of Wyoming and the Bradner Consulting Group who demonstrated a workable technique for coupling economic and ecological models. Outcomes: This technique allows decision makers **to assess tradeoffs among alternative fisheries practices** in a way that

captures both direct and indirect economic consequences. The researchers presented their findings to the Sustainable Fisheries Goal Implementation Team for the Chesapeake Bay Program.

Another MDSG project created an integrated bioeconomic model to evaluate both the economic and biological effects of alternative policies on the Chesapeake Bay blue crab fishery. Outcomes: The model, developed by scientists from UMCES and Texas A&M University, yielded specific policy recommendations. Among them: a short fishing season for female crabs combined with a long fishing season for males appears to increase both sustainable yield and revenue. Their findings were published in the *North American Journal of Fisheries Management*.

• **Magazine journalism to educate the public.** To inform non-technical audiences about EBFM, MDSG focused a double issue of our magazine, *Chesapeake Quarterly*, on this topic in 2011 and distributed it to our 5,000 subscribers in various environmental, educational and resource management communities. Our outreach expanded when the lead article from this issue, "Food Fight: Ecosystem-Based Fisheries Management and the Menhaden Wars," was then republished in 2012 in *Chesapeake Bay Magazine*, a long-standing regional publication that reaches more than 50,000 readers.

Outcomes for Science: Scholarly Publications

Maryland Sea Grant supported research that led to 95 scholarly publications in 60 journals, five of them open access, in 2010-2013. In all, these publications have received more than 1,100 citations. Of these publications, 30 resulted from projects in this focus area.

PIER PRP Program Focus Area Report

Maryland Sea Grant

Safe and Sustainable Seafood Supply

Program Focus Area: Sustainable Natural Resources of Coastal Maryland

Program Goals

1. Improve scientific foundations for managing, conserving and restoring natural resources
2. Develop technologies for restoration, aquaculture and marine products
3. Implementation of ecosystem-based fisheries management in Chesapeake Bay
4. Informed consumers who understand the importance of ecosystem health and sustainable harvesting practices to the future of our domestic fisheries, who appreciate the health benefits of seafood consumption, and who understand how to evaluate the safety of the seafood products they buy.

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[Full Text of Impacts](#)

[Program Performance Measures](#)

[Objectives](#)

Impacts and Accomplishments toward Program Goals

1. Program Goal: Improve scientific foundations for managing, conserving and restoring natural resources

Impact(s)

- o [20679](#) - Genetic Tool to Detect Harmful Crab Virus Is Developed and Disseminated
- o [17215](#) - Blue Crab License Buy Back Assistance
- o [17061](#) - Large-Scale Blue Crab Recruitment Limitation in Upper Chesapeake Bay Nurseries: Dispersal and Post-Settlement Processes

Accomplishment(s)

- o [18439](#) - Using Molecular Monitoring to Study Virus that Increases Mortality of Soft Shell Crabs
- o [17724](#) - Program Development Funds: Supporting Research and Education in Fisheries
- o [17436](#) - Chesapeake Quarterly Magazine Explores Challenges Facing Fisheries
- o [16977](#) - Intrapopulation Biodiversity and Recruitment Pathways for Chesapeake Striped Bass
- o [15693](#) - Marine Resources Economics Fellowship (DePiper)
- o [15645](#) - NOAA Coastal Management Fellowship Awarded to Wesley Bickford
- o [15065](#) - Dynamics of Ichthyoplankton Ingress from the Coastal Ocean into Chesapeake and Delaware Bays: Comparing Spatiotemporal Concordance and Transport Mechanisms

2. Program Goal: Develop technologies for restoration, aquaculture and marine products

Impact(s)

- o [20697](#) - In-Situ Enclosures Enhance Oyster Larvae Set in Chesapeake Bay
- o [18367](#) - Maryland Sea Grant Extension Supports Food Safety in the Seafood Industry
- o [18361](#) - Remote Setting Training Program Helps Growers to Produce Oyster Seed for Aquaculture
- o [18359](#) - Oyster Hatchery Produces 1.2 Billion Spat for Aquaculture and Restoration
- o [16979](#) - Analyzing 70 Years of Oyster Monitoring Data to Help Guide Oyster Restoration in Maryland
- o [14248](#) - Cryogenic Processing, Packaging, and Marketing of Crab Meat

Accomplishment(s)

- o [20674](#) - Developing Seaweed Aquaculture to Control Nutrients from Oyster Aquaculture and Provide Feedstock
- o [16971](#) - Sea Grant Aquaculture Research Program: Predicting Spatial Impacts of Bivalve Aquaculture on Nutrient Cycling and Benthic Habitat Quality
- o [15061](#) - Sea Grant Aquaculture Extension: Evaluation of Innovative Practices for Aquaculture Development

3. Program Goal: Implementation of ecosystem-based fisheries management in Chesapeake Bay

Impact(s)

- o [18441](#) - Coupled Economic and Ecological Models for Fisheries Management in the Chesapeake Bay
- o [15743](#) - Facilitating the Development of Ecosystem Based Fisheries Management in the Chesapeake Bay

4. Program Goal: Informed consumers who understand the importance of ecosystem health and sustainable harvesting practices to the future of our domestic fisheries, who appreciate

the health benefits of seafood consumption, and who understand how to evaluate the safety of the seafood products they buy.

Impact(s)

- [15787](#) - Extension Supports Training Programs in Seafood Safety

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Full Text of Impacts and Accomplishments

20697 - In-Situ Enclosures Enhance Oyster Larvae Set in Chesapeake Bay

RELEVANCE: A priority of the state of Maryland and federal policy makers is to promote oyster aquaculture in Chesapeake Bay and restore its wild oyster population, which has been greatly reduced by oyster diseases, overfishing, and other factors. Current restoration methods include planting hatchery-reared oyster larvae (spat) on oyster shell and placing the spat-on-shell on existing reefs or on shell substrate put on the Bay's bottom as habitat. However, availability of the preferred shell substrate is in short supply and so the researchers in this project investigated the efficacy of an alternative technique to improve the set rates of oyster larvae.

RESPONSE: Maryland Sea Grant supported the principal investigators, Cecily Steppe and David W. Fredriksson of the U.S. Naval Academy, to design and build an enclosure system, similar to an oil boom, to contain the larvae. Shell was added to form a "reef" inside the enclosure. Measurements of spat set were made within enclosed areas with and without shell substrate placed on the bottom. The researchers measured larvae mortality one month after the larvae were deposited and again the following spring. The researchers also measured how well the enclosure moderated the effects of tides, currents, and boat wakes.

RESULTS: The researchers concluded that the enclosure and associated mooring system effectively retained and protected oyster larvae, resulting in more spat set inside the enclosure than outside. An economic analysis indicated that this approach had relatively high costs for labor and equipment but could be cost-effective under certain circumstances -- for example, oyster larvae could be set without bottom shell substrate if the substrate becomes more difficult to obtain and/or expensive to transport. The researchers provided detailed information on this work to state agencies and academic institutions interested in replicating this work in other locations (e.g., New York, New Jersey, and Louisiana.) The researchers shared their findings with two commercial aquaculture companies, one of which, Shore Thing Shellfish, secured a grant to modify the enclosures and use them in their own aquaculture shellfish production. Results were also presented to scientific audiences at multiple local meetings and the International Conference on Shellfish Restoration. The findings served as a basis for a K-12 curriculum on aquaculture and environmental engineering taught to more than 400 middle school and high school students.

RECAP: Researchers demonstrated the efficacy of a new method to increase the deposition (spat set) and survival of oyster larvae onto oyster reefs in Chesapeake Bay. This finding expands the toolkit available for helping to restore wild oyster populations and boost oyster aquaculture in the Chesapeake, improving a fishery that historically was vital economically and culturally. [Back to Goals](#)

20679 - Genetic Tool to Detect Harmful Crab Virus Is Developed and Disseminated

RELEVANCE: Soft-shell crab production is plagued by mortalities of 25 percent or more. The principal investigators discovered that most of these deaths are associated with a crab-specific virus called reo-like virus (RLV). This virus causes heightened mortality of crabs in laboratory experiments and may increase mortality rates in facilities that produce soft-shell crabs in captivity (referred to as shedding systems). In these facilities, crowding of crabs may promote transmission of RLV among injured, stressed individuals. In addition, some operators discard dead crabs into nearby waterways while their shedding systems discharge water to those same water bodies, offering a potential route for RLV to infect wild crabs.

RESPONSE: This research study, supported by Maryland Sea Grant, was strengthened by repeated sampling at the same locations in Chesapeake Bay. The application of the PCR (polymerase chain reaction) assay enabled confirmation that RLV prevalence in the estuary is highly variable both spatially and temporally. Through a competitive process, Emily Flowers was selected as a Maryland Sea Grant Research Fellow and conducted research on this project.

RESULTS: Researchers shared the PCR assay tool with colleagues who are applying it to better understand RLV. One of the principal investigators made a presentation to the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team. The Florida Fish and Wildlife Research Institute has collaborated with one of the investigators, Eric Schott of the University of Maryland Center for Environmental Science, to use the tool to study the prevalence of the virus in Florida waters; results of this study confirm that RLV is present along Florida's Gulf coast. At the request of a Louisiana Sea Grant fisheries specialist, the Schott lab confirmed RLV in that state, a finding now published in two manuscripts. As a follow up, Dr. Schott and a colleague submitted a proposal to a national Sea Grant competition for funds to conduct workshops in Maryland and Louisiana and to partner with fishermen to develop improved shedding practices to reduce the effects of RLV.

RECAP: Researchers developed a PCR assay tool to detect a crab-specific virus that is associated with high mortality during the production of soft-shell blue crabs. This tool, developed for use in

Chesapeake Bay, is now used by researchers in Florida and Louisiana for studies of the prevalence of reo-like virus (RLV) in coastal waters there. [Back to Goals](#)

20674 - Developing Seaweed Aquaculture to Control Nutrients from Oyster Aquaculture and Provide Feedstock

RELEVANCE: Maryland state agencies have been promoting large-scale oyster farming in Chesapeake Bay because of its benefits to the state's economy and environment. In addition to jobs and income associated with oyster cultivation, oysters provide environmental benefits by removing nutrients from the surrounding water and potentially improving water quality. However, intensive aquaculture can concentrate high nutrient loads from oyster wastes that could promote harmful algal blooms and deplete oxygen in bottom waters. If macroalgae (seaweeds) can be grown on a commercial scale near oyster farms, they could serve as biofilters to remove excess nutrients. They could also be harvested for marketable products such as feed and biofuels; there is a global shortage of *Gracilaria* seaweed. This would provide oyster aquaculture businesses additional income while allowing them to develop their operations in an environmentally sustainable way.

RESPONSE: In 2014, researchers supported by Maryland Sea Grant expanded on earlier developmental work by testing aquaculture of a species of a red alga (genus *Gracilaria*) native to the Chesapeake at four sites around the bay. The algae were grown on ropes in the water.

RESULTS: The researchers demonstrated the environmental and economic benefits of macroalgae aquaculture: researchers estimated an annual productivity of 6 metric tons dry weight of *Gracilaria* per acre per year. This harvest contained an estimated 13,500 pounds of carbon dioxide, 300 pounds of nitrogen, and 25 pounds of phosphorus. The researchers estimated net revenues of \$3,300 per acre, which compared favorably with net revenues from growing corn (\$373 per acre) and soybeans (\$252 per acre) on land. The researchers presented their findings to oyster aquaculture businesses in the Chesapeake region. They also collaborated with a Baltimore company, TIC Gums Inc., one of the major distributors of agar in the United States; the company tested the algal biomass as agar feedstock. The researchers also collaborated with abalone aquaculture operations outside Maryland to test *Gracilaria* as a feedstock for abalone. And they worked with a Chinese seafood-and-aquaculture company to continue developing seaweed aquaculture in the Chesapeake. The researchers are discussing with investors opportunities to scale up commercial production of *Gracilaria* in Chesapeake Bay.

RECAP: Researchers developed and demonstrated the value of integrating seaweed (macroalgae) aquaculture with oyster aquaculture in Chesapeake Bay. This integration can provide an economically valuable secondary crop (algae for biofuels or feedstock) while improving the Chesapeake's water quality because of the seaweed's ability to sequester excess nutrients from the water. [Back to Goals](#)

18441 - Coupled Economic and Ecological Models for Fisheries Management in the Chesapeake Bay

RELEVANCE: Traditional fisheries management largely regulates harvests by setting limits on catch sizes and quantities. Because such limits do not account for the impacts on food web and predator-prey interactions, natural resource agencies have been moving towards Ecosystem Based Fishery Management (EBFM), which aims to account for the effects of policy on harvests, habitat, and water quality. However, EBFM does not consider the economic impacts of fisheries management in policy, for example, on employment, income, and business profits. The ability to couple ecosystem models with economic models could provide decision makers with sophisticated tools for assessing trade-offs of alternative fisheries management policies.

RESPONSE: Scientists from the University of Wyoming and the Bradner Consulting Group Inc. studied the feasibility of combining an ecological model with an economic model for Ecosystem Based Fishery Management, both based on data from the Chesapeake Bay.

RESULTS: The research team demonstrated that by coupling economic and ecological models, decision makers will have the ability to assess tradeoffs between alternative fisheries and habitat policies in a way that captures both direct and indirect consequences throughout the regional economy.

The researchers presented the results of this study to the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team, composed of state fisheries managers and a diverse group of scientists. Discussion of the presentation indicated that other fisheries and ecosystem models currently available or being used in Chesapeake Bay decision making could be coupled to the research team's economic model.

The research team showed that fishery management decisions based on a single species modeling approach can differ significantly from decisions based on coupled models. The team encouraged further development of these types of models for Chesapeake Bay management.

RECAP: This project demonstrated that coupled ecosystem and economic models have the potential for providing sophisticated assessments of the effects of alternative fisheries management policies. [Back to Goals](#)

18439 - Using Molecular Monitoring to Study Virus that Increases Mortality of Soft Shell Crabs

RELEVANCE: Soft shell crab production is an important commercial activity in Chesapeake Bay. This type of production, in flow-through systems that use water from Chesapeake Bay tributaries, has been plagued by high crab mortalities caused by a reo-like virus (RLV.) One unknown is the cause and

frequency of viral outbreaks in these shedding systems. A second unknown is whether the systems' water discharge back into tributaries contributes to increased viral prevalence in the surrounding water.

RESPONSE: Researchers at the University of Maryland Center for Environmental Science and the Smithsonian Environmental Research Center developed a tool to assess viral prevalence - a fast quantitative assay employing a reverse transcription PCR (polymerase chain reaction). The scientists assessed viral prevalence in more than 1000 wild crabs from three regions. Crabs were collected in areas near and distant from crab shedding operations to determine (1) if harvested crabs were carriers of RLV and (2) whether there was a correlation between shedding system effluents and RLV prevalence.

RESULTS: While researchers found no consistent correlation of viral prevalence in crabs close to shedding operations, they did find surprisingly large swings of prevalence in crabs throughout the sampled regions and over brief times, a finding that raises questions about how quickly viral outbreaks can begin and end. The researchers learned that many watermen dump dead crabs into fishing grounds, a practice that could increase viral prevalence in those locations. The research team discussed with the Maryland Department of Natural Resources potential practices by shedding operations and watermen that would improve their safe disposal of dead crabs. The research team has presented these findings at the annual East Coast Commercial Fishermen's & Aquaculture Trade Exposition and is working with Maryland Sea Grant Extension on targeted outreach efforts to watermen to advise them about safer disposal practices.

RECAP: Researchers developed a fast quantitative PCR assay to study the prevalence of a crab-specific virus in Chesapeake Bay tributaries that can cause high crab mortality in flow-through shedding operations. The tool has shown for the first time that the virus' prevalence varies widely over space and time. The researchers informed state regulators and watermen about practices that could reduce the prevalence of this virus. [Back to Goals](#)

18367 - Maryland Sea Grant Extension Supports Food Safety in the Seafood Industry

RELEVANCE: The commercial blue crab industry is an important part of the Maryland economy. Between 2009 and 2012, commercial landings of blue crabs reached an average of nearly 50 million pounds worth an estimated \$57 million. Crucial to this fishery are Maryland's crab processors, who process crab meat for sale across the region. These businesses, however, face steep competition from imported crab meat, and many struggle to produce quality products while still remaining profitable. Since many seafood products can transmit human pathogens, ensuring the safety of Maryland seafood has become central to marketing products like crab meat.

RESPONSE: In an ongoing project, MDSGEP's seafood technology specialist oversaw the Maryland Crabmeat Quality Assurance Program. The program was designed to limit the transmission of disease-causing bacteria and the pathogen responsible for Listeria infections among people. Participants agreed to undergo inspections for food safety violations that went beyond what was required by law. In return, the businesses had the opportunity to print a specially designed logo on their products in 2013 that promoted their adherence to these high standards of quality.

RESULTS: In 2013, 15 Maryland seafood processors participated in the Maryland Crabmeat Quality Assurance Program. Previous economic analyses have estimated that this program increases the sales of participating businesses by 15 percent, translating to over \$3.5 million in economic benefits.

RECAP: The Maryland Sea Grant Extension Program's (MDSGEP) seafood technology specialist supported crab processors across the state through a voluntary program that improves the safety of local seafood. [Back to Goals](#)

18361 - Remote Setting Training Program Helps Growers to Produce Oyster Seed for Aquaculture

RELEVANCE: The state of Maryland in 2010 made legislative changes aimed at encouraging the development of oyster aquaculture, and this industry has grown tremendously as a result. Regional entrepreneurs already hold more than 200 leases for aquaculture plots in the Chesapeake Bay and its tributaries. Oyster farms add to local coastal economies and provide income for Marylanders, including watermen who once depended solely on the harvesting of wild oysters. In addition, oyster aquaculture farms often contribute to the reduction of nutrients and sediment in the water column, helping to improve water quality in the Chesapeake Bay and its tributaries.

One substantial cost for oyster growers is obtaining spat on shell, or larvae that have attached to recycled shells, to grow the next generation of oysters. Natural spat set is rare on aquaculture plots, requiring growers to purchase and transport this seed from hatcheries.

RESPONSE: MDSGEP's Eastern Shore agent has directed the Remote Setting Training program since 2011 in conjunction with the Oyster Recovery Partnership and with funding from the Maryland Department of Natural Resources. This program operates several remote setting systems across the state. These systems teach users to set oyster larvae grown at a hatchery onto shells -- creating their own spat on shell -- which they can then place on their aquaculture plots for growout.

In 2013, the RST program rented its systems over two-week time spans to regional aquaculture businesses to help them produce the spat on shell needed for their plots. The agent and his

collaborators trained growers in how to successfully complete remote setting procedures. Team members also conducted follow-up visits to measure the success rate of the setting process in the remote setting tanks.

After one to two years in the RST program, growers are expected to build their own remote setting systems. The agent and his collaborators provided ongoing technical assistance to growers during this process in 2013.

RESULTS: In 2013, the RST program operated remote setting systems at nine sites around Maryland, which incorporated a total of 31 production tanks. Twenty-seven growers participated in the program, an increase from 17 in 2012. These participants produced an estimated 278 million oyster spat in 2013, compared to 211 million the previous year. Additionally, four growers installed their own systems, producing an estimated 50 million additional spat.

RECAP: The Maryland Sea Grant Extension Program (MDSGEP) operated the Remote Setting Training (RST) program to support state oyster growers, resulting in the production of 278 million oyster spat on shell (larvae attached to shells) for aquaculture enterprises. [Back to Goals](#)

18359 - Oyster Hatchery Produces 1.2 Billion Spat for Aquaculture and Restoration

RELEVANCE: The state of Maryland has dedicated considerable resources to restoring oysters to the Chesapeake Bay. The estuary's oyster populations declined dramatically beginning in the 1950s as a result of overfishing and disease. The loss contributed to worsening water quality in the Bay and its tributaries and has deprived commercial watermen in Maryland of income. Efforts to restore oyster populations are expected to provide habitat for fish and other animals, help to reduce nutrients and sediments in the estuary, and enhance the Maryland economy. Both wild oyster restoration projects and aquaculture businesses, however, require a supply of oyster shell and larvae in order to build new reefs and stocks.

RESPONSE: The Horn Point Oyster Hatchery, directed by MDSGEP's shellfish aquaculture specialist in partnership with government agencies and non-governmental organizations, is among the largest operations of its kind on the East Coast of the United States. Using new methods and technologies, the hatchery produces spat on shell -- oyster larvae that have attached to shells.

The hatchery's partners use this oyster spat to seed or supplement restored oyster reefs in the Chesapeake Bay and its tributaries. Regional oyster aquaculture growers also need large numbers of spat to produce the next generation of oysters at their growing sites.

RESULTS: MDSG's aquaculture specialist directed the production of 1.2 billion spat on shell in 2013 at the Horn Point Oyster Hatchery, a record number. Additionally, the hatchery sold \$113,000 worth of oyster shell to aquaculture enterprises in the state. To help reduce start-up costs for new aquaculture enterprises, the hatchery also donated spat valued at \$156,000 to regional oyster aquaculture growers.

RECAP: The Maryland Sea Grant Extension Program's (MDSGEP) shellfish aquaculture specialist and his staff produced more than one billion oyster "spat on shell" (oyster larvae that have attached to shells) through the Horn Point Oyster Hatchery in 2013 and donated \$156,000 worth of spat to regional oyster growers. [Back to Goals](#)

17724 - Program Development Funds: Supporting Research and Education in Fisheries

RELEVANCE: Program development funds provided an opportunity to advance our efforts in education and outreach on fisheries and aquaculture issues important to Maryland, the region, and beyond in areas that are not traditionally supported through our other funding streams.

RESPONSE: We used our program development funds to provide small contributions and support in areas where we recognized a strategic need, noting that small funding could have big results. The activities we supported often included partnerships with other groups and other funding streams so that we could meet our state and national priorities with limited resources.

RESULTS: One research project investigated the conditions of the soft and hard clam populations in Maryland. The investigators confirmed that the continuing decline in the Maryland softshell and razor clam populations resulted not from several severe storms and hurricanes in 2011 and 2012, but from a complex mix of temperature, disease, predation, and fishing pressure. Another research project on parasites of spearfish and marlin species discovered a possible new parasite species, resulting in a publication and funding of \$24,500 to purchase a microscope to support further study of parasites of this important fish. In addition, we provided partial support for the Northeast Aquaculture Conference and Exposition biennial meeting that brought together aquaculture researchers and practitioners to share knowledge.

RECAP: Maryland Sea Grant used program development funds for a variety of research and outreach projects. Our support for shellfish and fisheries research and for aquaculture meetings resulted in publications, information for commercial fisherman, and new research funding. [Back to Goals](#)

17436 - Chesapeake Quarterly Magazine Explores Challenges Facing Fisheries

RELEVANCE: Oysters and blue crabs are some of the Chesapeake Bay's most important fisheries, both in shaping the region's culture and providing a livelihood to watermen. Statewide, the blue crab fishery has an annual dockside value of \$52.9 million. An important part of Maryland Sea Grant's outreach

activities is producing popular publications that explain scientific research and possible solutions relevant to these and other problems facing the Bay.

RESPONSE: In 2012, Maryland Sea Grant's communications team produced two issues of our award-winning magazine, Chesapeake Quarterly, which focused on scientific research pertinent to Bay fisheries. The issues featured original stories and photography by Sea Grant staff.

The first issue, "Acid Test for the Shellfish Bay" (March 2012), explored in 16 pages how ocean acidification might impact populations of oysters in the Bay, which are already vulnerable because of past overfishing and disease. A second, special 20-page issue, "Tracking the Blue Crab Comeback" (July 2012), investigated the recent resurgence of blue crab populations in the Bay, which has been credited both to changes to fisheries management and natural shifts in climate.

Both magazine issues used engaging language and narrative appropriate for general readers. They also delved into potential solutions to these long-term problems.

RESULTS: The two issues were mailed to the nearly 5,000 subscribers of the print version of the magazine. The issues were also published online for our large web audience.

RECAP: Maryland Sea Grant communications staff produced two issues of our award-winning news magazine, Chesapeake Quarterly, delving into threats to two prominent Bay fisheries: oysters and blue crabs. [Back to Goals](#)

17215 - Blue Crab License Buy Back Assistance

RELEVANCE: Maryland's blue crab fishery has long been the state's most productive fishery, generating an estimated \$500 million in economic benefits each year. Fisheries managers around the state are working to ensure the ongoing sustainability of crab harvests despite natural fluctuations in populations.

RESPONSE: Continuing work begun in 2011, Maryland Sea Grant Extension economist Douglas Lipton helped the state to design and implement an innovative program for decreasing the fishing pressure on blue crabs. Using disaster relief funds from NOAA, Maryland offered to purchase commercial blue crab fishing licenses from license holders who hadn't harvested crabs for an extended period of time. If those licensees had returned to fishing, the Bay's crab stocks could have declined significantly because of the additional fishing pressure.

Lipton helped the state to calculate a fixed price (\$2,360) that would be offered for Limited Crab Catcher licenses, one type of commercial license. He also designed a reverse auction buy back program to help the state purchase unused Tidal Fish Licenses, another type of license that allows bearers to harvest crabs. Geret DePiper, a Maryland Sea Grant graduate research fellow in economics, contributed to this work.

RESULTS: In 2012, the state of Maryland purchased 15 unused crab fishing licenses at costs ranging from \$4,000 to \$9,000, generating income for the license-holders and limiting fishing pressure on the Bay's crab populations. An economic analysis estimates that these purchases will generate \$104,000 in economic benefits for the state. (This is an update about the same project for which Maryland Sea Grant submitted an Impact statement for 2011.)

RECAP: Maryland Sea Grant Extension agents helped the state to design and conduct a "buy back" program for unused blue crab fishing licenses, generating income for license holders and reducing the fishing pressure on crab populations. Crab license purchases are estimated to generate \$104,000 in benefits for the state. [Back to Goals](#)

17061 - Large-Scale Blue Crab Recruitment Limitation in Upper Chesapeake Bay Nurseries: Dispersal and Post-Settlement Processes

RELEVANCE: The Chesapeake Bay's blue crab population declined during the 1990s, a trend that has correlated with reductions in spawning females and, as a result, juveniles. This project used field sampling and spatial modeling to understand the dispersal of juvenile blue crabs in key nurseries in the upper Bay -- information that can inform fishery management to help facilitate stock restoration.

RESPONSE: The principal investigators on this completed project were Eric Johnson, Denise Breitburg, and Anson Hines, all of the Smithsonian Environmental Research Center.

RESULTS: In this completed study, the first of its kind, the researchers' findings supported the hypothesis that important nursery habitats were recruitment-limited (receiving relatively few juvenile crabs), which contributed to the lack of population recovery. These findings supported an earlier series of studies by these researchers, who found evidence that tended to rule out other alternative explanations -- such as predation, inadequate food supply, and poor water quality -- for the low numbers of juveniles in the nurseries.

Based on their earlier studies, the investigators had advised natural-resource managers in Maryland and Virginia that restricting the winter harvest of female blue crabs would tend to increase numbers of juveniles reaching nursery grounds in the upper Chesapeake Bay and so would contribute to the

population's growth. One of the principal investigators, Eric Johnson, served on the Chesapeake Bay Stock Assessment Committee that made this recommendation formally. As a result, in 2008 the states of Maryland and Virginia jointly banned the winter harvest of female blue crabs. By 2012, the Bay's total estimated population of blue crabs had more than doubled. This research project provided continuing supporting evidence after 2008 for the efficacy of the harvest ban as a means to help increase the Chesapeake Bay's population of blue crabs. This was an important contribution given that the post-2008 population growth led to calls for reversing the ban.

RECAP: This project has provided supporting evidence for continuing a ban on harvesting female blue crabs as a means to help increase the population of blue crabs in the Chesapeake Bay. [Back to Goals](#)

16979 - Analyzing 70 Years of Oyster Monitoring Data to Help Guide Oyster Restoration in Maryland

RELEVANCE: Management activities to rebuild the Chesapeake Bay eastern oyster population have achieved limited success. One reason is that the magnitude of oyster spatfall (settling and attachment of larvae to substrate) varies spatially and between years. This variability is driven both by water quality conditions affecting larval production and also by variation in quantity and condition of substrate (shell) for larval settlement. Restoration efforts can include renovating oyster bars by uncovering buried shell and placing fossil shell on bars. Researchers in this project have developed a model that can predict which locations have the greatest likelihood of receiving above-average spatfall under prevailing weather conditions. The model could allow natural-resource managers to better focus these restoration efforts.

RESPONSE: The principal investigators of this project are Roger I.E. Newell, University of Maryland Center for Environmental Science Horn Point Laboratory; David G. Kimmel, East Carolina University; and Mitchell Tarnowski, Maryland Department of Natural Resources. The researchers have used historical data, climate models, and the statistically derived relationship between oyster spatfall and salinity/temperature to make spatial predictions about spatfall.

RESULTS: The findings provided supporting evidence for a decision by the U.S. Army Corps of Engineers to locate a major, multi-year oyster restoration project in Harris Creek, a tributary of the Choptank River in Maryland. This project will serve as an important test case of oyster restoration methods in the Chesapeake Bay generally. The researchers' model indicated that weather patterns that produce wet conditions led to lower salinity and to reduced juvenile oyster abundance; weather patterns that produce dry conditions resulted in higher salinity and higher juvenile oyster abundance. The results indicate that the model can predict regions of higher juvenile oyster abundance several months in advance.

RECAP: Researchers have developed a model to predict which locations have the greatest likelihood of receiving above-average oyster spatfall (settling of larvae onto hard substrate), taking into account the effect of wet versus dry years. This model would allow managers to better focus restoration efforts by identifying the locations where oyster bar rehabilitation will result in the greatest increase in oyster abundance. The model should also be useful to commercial aquaculture operators seeking to maximize their production. [Back to Goals](#)

16977 - Intrapopulation Biodiversity and Recruitment Pathways for Chesapeake Striped Bass

RELEVANCE: Back from the brink after a fishing moratorium, striped bass tell a dramatic success story of species recovery. The researchers in this study examined the diversity in age structure within the population and its role in the population's recovery. As stress on living resources in the Chesapeake Bay and other coastal ecosystems increases, it is important to understand how such intra-population variability contributes to the sustainability and resiliency of fish populations.

RESPONSE: The principal investigators on this completed study are Thomas J. Miller and David Secor of the Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, and Allen Place, Institute of Marine and Environmental Technology, University System of Maryland. The researchers examined, among other questions, whether reproductive diversity influences recruitment (the number of new young fish surviving to enter the adult population.)

RESULTS: The researchers became the first group to sequence the entire striped bass mitochondrial genome. Based on this sequence, they have conducted an analysis that confirmed that the temperate sea basses are all descendants of a common ancestor.

The results suggest that despite the existence of high variation in egg phenotype (and presumptively, maternal phenotype) in the population, no particular phenotype appears to lead to greater reproductive success.

The researchers classified striped bass into resident (individuals that remained in freshwater habitats of salinity = 3) and migratory contingents (those that dispersed to brackish water habitats of salinity > 3). Most migrants dispersing down-estuary from freshwater natal habitats did so during the juvenile period. Migratory choices were influenced by early growth, which, in turn, was influenced by the date of hatch. Residents experienced accelerated early growth relative to most migrants and tended to have later hatch dates, suggesting better early conditions for larvae as the spawning season progressed. The trophic position, post-migration growth, and trophic niches of juveniles did not differ between habitats.

RECAP: Using striped bass as a model, this completed study employed traditional fisheries science approaches, combined with state-of-the-art chemical analyses and molecular genetics, to quantify the role of diversity in population resilience among spawning females and their offspring. [Back to Goals](#)

16971 - Sea Grant Aquaculture Research Program: Predicting Spatial Impacts of Bivalve Aquaculture on Nutrient Cycling and Benthic Habitat Quality

RELEVANCE: This ongoing research seeks to quantify the effects of bivalve aquaculture on the surrounding ecosystem and to develop design guidelines to help mitigate any possible adverse effects. An impediment to the expansion of shellfish aquaculture is the often considerable opposition to the use of public waters due to perceived adverse environmental consequences. This project also seeks to enhance knowledge of interactions between aquaculture and the environment that may lead to sustainable production practices, boost the aquaculture industry, and provide jobs and incomes to coastal communities. Another benefit may be to enhance benthic denitrification.

RESPONSE: The principal investigators of this research project are Roger I.E. Newell, Jeffrey C. Cornwell, and Lawrence P. Sanford of the University of Maryland Center for Environmental Science, Horn Point Laboratory. In this reporting period the researchers worked in cooperation with the Marinetics oyster aquaculture farm in the Chesapeake Bay. Through field studies, they quantified deposition, resuspension, and dispersal of oyster feces and pseudofeces and changes in sediment characteristics. The researchers are using these data to obtain a quantitative understanding of the relationships between dispersal and breakdown of particulate waste generated from shellfish aquaculture relative to the physical characteristics of a site and the seasonal variability of oyster feeding.

RESULTS: The researchers performed four week-long seasonal field studies to measure rates of deposition of organic nitrogen and carbon from oyster feces and pseudofeces settling underneath oyster floats. They largely completed development of a Flow 3-D model to assess water flow around and through the aquaculture sites. They can now incorporate in the model their field data on particulate waste production by oysters and mussels and the settling velocity of these various-sized particles.

The researchers have been in extensive contact with the Seafood Quality Standards Coordinator for Whole Foods Market. Whole Foods is working towards the goal of selling shellfish raised in aquaculture farms in a manner to minimize adverse ecological effects.

RECAP: This ongoing research project is quantifying the effects of off-bottom oyster and mussel aquaculture (i.e. on floats) on sediments and surrounding water. The researchers are working to predict the influence of oyster and mussel farms on nutrient processes and to mitigate possible adverse effects. [Back to Goals](#)

15787 - Extension Supports Training Programs in Seafood Safety

RELEVANCE: Seafood contamination by disease-causing pathogens, including Salmonella and the bacterium Listeria monocytogenes, represents a serious health risk to U.S. consumers. In 2005, the Joint Institute for Food Safety and Applied Nutrition (JIFSAN) launched a training program throughout Asia with the goal of reducing Salmonella outbreaks and antibiotics use in aquaculture-industry products destined to be exported to the U.S. The U.S.-based Seafood HACCP Alliance trains regional seafood processors and regulators in the U.S. to meet cleanliness standards set out by the FDA's HACCP program.

RESPONSE: Using curricula developed and updated by Maryland Sea Grant Extension agent Tom Rippen, JIFSAN "train-the-trainer" workshops have been held in Vietnam, Thailand, Malaysia, Bangladesh, and China. Rippen coordinated the first such workshop, held in India in January 2012. He continued to draw on the best available science to update the Seafood HACCP Alliance's training program. He coordinated four training courses for the alliance in 2011. Rippen also designed a new training program, which U.S.-based HACCP trainers must take to renew their certifications.

RESULTS: India's JIFSAN training program drew 49 participants from the public and private sectors, and regulators report a general trend toward improved sanitation and antibiotics use in the aquaculture industry in Thailand, Vietnam, and Indonesia. Workshops coordinated by Rippen in the U.S. included 166 participants. Anecdotal evidence suggests that HACCP compliance has increased across seafood processing plants in the U.S.

RECAP: A Maryland Sea Grant Extension agent developed educational materials and conducted training workshops both in the U.S. and abroad aimed at slowing the spread of human pathogens through commercially sold seafood. [Back to Goals](#)

15743 - Facilitating the Development of Ecosystem Based Fisheries Management in the Chesapeake Bay

RELEVANCE: Over the last decade, ecosystem based fisheries management has been discussed in fisheries research and policy circles and endorsed in the National Ocean Policy as a new and appropriate approach to fisheries management. However, few fisheries management regimes have actually moved forward to define and take action on such an approach. Maryland Sea Grant recognized the importance of this new policy direction and catalyzed the Chesapeake Bay fisheries science and management communities to undertake the development of a framework for pursuing ecosystem based fisheries management (EBFM) that goes beyond the traditional single-species management focus.

RESPONSE: Maryland Sea Grant (MDSG) worked to build an EBFM framework based on principles that included scientific consensus, ecological factors, and socioeconomic drivers. MDSG was uniquely positioned to facilitate this project because of the program's strong reputation as an unbiased platform for discussion and building consensus on Chesapeake Bay issues. In 2011, project teams completed management briefs on four important Chesapeake Bay species (allosines, striped bass, blue crab, and menhaden).

RESULTS: All four species briefs were distributed among the EBFM partners, including regulators at the Maryland Department of Natural Resources. In 2011, Maryland Sea Grant published a monograph, "Managing the Chesapeake's Fisheries: A Work in Progress," as part of its Chesapeake Perspectives series. This monograph summarized the state of fisheries in the Bay and the prospect for successful management through an EBFM process. Maryland Sea Grant solicited research proposals for study of socioeconomic aspects of EBFM for the Chesapeake Bay. Two proposals were selected and work began in early 2012. Although the EBFM process is currently on hiatus, the effort over the past five years resulted in one of the first complete frameworks for an EBFM process in the United States. This solid foundation is poised to support a new multi-species, ecosystem-centered approach to managing fisheries in the Chesapeake Bay.

RECAP: From 2007 to 2011, Maryland Sea Grant led an effort to develop a scientifically rigorous, ecosystem based fisheries management framework for the Chesapeake Bay, one of the first of its kind in the United States. [Back to Goals](#)

15693 - Marine Resources Economics Fellowship (DePiper)

RELEVANCE: Maryland Sea Grant encourages graduate students in Maryland to apply for this prestigious fellowship, which provides support for up to two years for a PhD student working in marine resource economics, natural resource economics, or environmental economics.

RESPONSE & RESULTS: Geret DePiper, a PhD student at the University of Maryland, College Park was one of only two students in the United States selected in 2010 for this prestigious Marine Resource Economics Fellowship. Mr. DePiper's doctoral work focuses on sustainable fisheries management through incentives and design for latent effort and fishery buybacks. In 2011, Mr. DePiper designed, piloted, and conducted a demographic and attitudinal survey of Maryland and Virginia watermen who were eligible to participate in the Potomac River, Maryland, and Virginia crab license buy-back program (described separately under Impact ID# 15780 for 2011). The survey data collected by DePiper were then matched with comprehensive fisheries harvest data collected by license type. Preliminary findings from this research were used to inform the Maryland Department of Natural Resources subsequent round of crab license buybacks.

RECAP: The Marine Resources Economic Fellowship, established in 1999, provides a unique educational experience to students who have an interest in careers related to the population dynamics and economics of conservation and management of living marine resources. [Back to Goals](#)

15645 - NOAA Coastal Management Fellowship Awarded to Wesley Bickford

RELEVANCE, RESPONSE, & RESULTS: Maryland Sea Grant helps to support this fellowship program, which matches highly qualified postgraduate students with state coastal zone programs for a two-year paid fellowship. This fellowship provides on-the-job education and training opportunities in coastal resource management and policy for postgraduate students. For 2011, three excellent candidates were put forward to NOAA for consideration. Wesley Bickford was selected and serves as a Coastal Management Fellow in the Coastal Management Office of the New Jersey Department of Environmental Protection. Wesley was also supported in 2009-2010 as a MDSG Research Fellow.

RECAP: NOAA coastal management fellowship awarded to MD Sea Grant funded research fellow. [Back to Goals](#)

15065 - Dynamics of Ichthyoplankton Ingress from the Coastal Ocean into Chesapeake and Delaware Bays: Comparing Spatiotemporal Concordance and Transport Mechanisms

RELEVANCE: Fish that spawn offshore and then move as larvae to estuarine nursery areas, such as Atlantic menhaden, Atlantic croaker, and American eel, support important components of commercial and recreational fisheries in the Chesapeake and Delaware bays. But the mechanisms that control their influx into these systems are poorly understood. This research seeks to increase understanding of physical processes that influence larval transport from coastal spawning areas to estuarine nurseries and thus enhance fisheries management planning and the design of regional monitoring programs.

RESPONSE: The researchers completed an intensive field program, the results of which have advanced knowledge of factors that influence ingressing larvae. They also developed a circulation model and enhanced a larval transport model to simulate fish larvae.

RESULTS: Patterns in the abundance and age of larvae that ingress to the Chesapeake Bay have been discerned. The researchers found that ingress, age at ingress, feeding incidence and success, and growth all experienced some degree of inter-annual variability. Unexpectedly, the year of lowest ingress, 2006-07, was the year when age at ingress was oldest, feeding success was highest, and growth rate was fastest. Age at ingress and growth rates both were highest in 2006-07, indicating that size was larger and ontogenetic stage of larvae was more advanced at the Bay mouth in this year. Feeding was size dependent in each year.

RECAP: The Delaware, Maryland, and Virginia Sea Grant programs have coordinated research efforts

to identify patterns in the timing and abundance of fish larvae (ichthyoplankton) that enter into Chesapeake and Delaware bays from offshore waters. [Back to Goals](#)

15061 - Sea Grant Aquaculture Extension: Evaluation of Innovative Practices for Aquaculture Development

RELEVANCE & RESPONSE: This project provided funding for an aquaculture specialist as complementary support to an existing team of specialists in Maryland that worked to support the development of shellfish aquaculture on a broad scale. The additional support enhances the team's effort by addressing potential roadblocks through a strong partnership with state and local governments, agencies, and industry members. The specialists evaluated Maryland's Aquaculture Enterprise Zones in order to determine their effectiveness and potential for adoption in other regions. MDSG's aquaculture specialist worked with the Oyster Recovery Partnership, Maryland Department of Natural Resources, and groups of Maryland watermen to develop and test the concept of Industry Reserve Production Cooperatives.

RESULTS: The team has developed an economic spreadsheet for estimating costs of remote setting oysters in Maryland to aid commercial oyster farms in evaluating costs of production. Spreadsheets for on-bottom and containerized culture of oysters are in production. These spreadsheets will allow current and potential oyster farmers to evaluate their businesses. Additionally these spreadsheets will help potential oyster farmers decide if they should enter an Aquaculture Enterprise Zone or acquire their own leases. This included investigating the potential for ecosystem markets in Maryland for oyster farms and for restored oyster reefs.

RECAP: Maryland Sea Grant provided technical support to expand and accelerate the adoption of oyster aquaculture practices in Maryland, the Mid-Atlantic Region, and the nation. [Back to Goals](#)

14248 - Cryogenic Processing, Packaging, and Marketing of Crab Meat

RELEVANCE: Seafood processors needed a faster, cheaper technique for extending the shelf life of blue crab meat. Though blue crabs are most popular with customers during the summer months, they are often most available to crabbers during the autumn months when crabs are migrating south. A technique better than pasteurizing was needed for extending the shelf life of blue crab meat and creating a year-round product that could compete with imported crab meat.

RESPONSE: When Chesapeake Seafood Industries Association asked for an alternative to pasteurization, the Maryland Sea Grant Extension specialist for seafood technology partnered with the Maryland Department of Natural Resources to test flash freezing techniques that could be used by small independent seafood processors. Working with federal Crab Industry Disaster Relief Funds, administered through DNR, the Sea Grant specialist examined the problems posed by freezing such as dehydration, protein denaturizing, structural damage, toughening of texture, off-flavors, and yellowing. Through careful testing, the team documented how cryogenic freezing could create a flavorful product that could be frozen, thawed, and sold as previously frozen.

RESULTS: The team worked out the pre-freezing preparations, the best freezing times, batch sizes, liquid nitrogen amounts, and packaging. In addition they tested and did cost-benefit analyses of three different freezer sizes. A total of six processing companies now use cryogenic freezing techniques -- three with privately funded equipment and three with equipment purchased through Disaster Relief Funds. The executive director of the Chesapeake Seafood Industries Association said it was a fantastically successful operation.

RECAP: Maryland Sea Grant Extension worked with the Chesapeake Bay Seafood Industries Association to evaluate and test techniques and technology for extending the shelf life of blue crab meat through flash freezing. [Back to Goals](#)

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Program Performance Measures (2010 - 2013)

Program Performance Measure	Program Plan Target (2010-2013)	Reported	Program Comments
Number of information portals derived from research to improve seafood production, seafood product quality, processing, handling, and safe consumption.	2	11	2010 - These are information products in support of our work on improving the safety of crab meat and other seafood products. 2011 - Work continues consistent with 2010 2012 - Developed new website dedicated to aquaculture topics, current and upcoming programs, archived material from prior educational programs, pdf copies of publications, and links to partner sites (Webster - 1 actual, 1 anticipated). Electronic media have been used to develop training programs in seafood regulatory

			<p>compliance, including domestic and foreign HACCP train the trainer programs and Good Aquaculture Practices (Rippen - 4 actual, 4 anticipated). 2013 - Webster - 2 actual, 2 anticipated (Expansion of new website with integration of Facebook account for Maryland aquaculture and inclusion of new photo and video components) Brainard - 2 actual, 2 anticipated (New seafood safety and seafood technology portals on MDSG website)</p>
Number of quantitative reference points derived from research to improve seafood production, seafood product quality, processing, handling, and safe consumption.	3	0	<p>2010 - We anticipate improvement in this area by 2012. 2011 - This is limited due to a hiatus in EBFM activities by regional, state and federal fisheries managers. 2012 - One project is currently assessing quantitative reference points (Rp/FISH-256). Species briefs were previously developed through the regional EBFM process, which has since gone on hiatus. 2013 - One project is currently assessing quantitative reference points (Rp/FISH-256). Species briefs were previously developed through the regional EBFM process, which has since gone on hiatus.</p>
Number of resource managers and seafood businesses (harvesters, aquaculturists, processors and recreational fishermen) whom adopt and implement responsible harvesting and processing techniques and practices.	6	241	<p>2011 - Marinetics seaweed aquaculture collaboration. Maryland DNR-Fisheries, Oyster Recovery Partnership and Virginia Marine Resources Commission. [2010] - Included 2011 partners plus Captain's Choice seafood and seafood processors using cryogenic freezing technologies. 2012 - Approximate number based on presentation given at the 2013 Maryland Waterman's Commercial Fishing and Aquaculture Expo and Tradeshow (Parker - 5 actual, 5 anticipated). Number of new lease applications was ~100 with 66% including commercial harvesters as primary or partner applicant (Webster - 125 actual, 75 anticipated). Actively worked and advised Maryland DNR (as Fisheries Economist) and ASMFC (as Maryland representative in the Committee on Economics and Social Sciences). In 2013 the plan is also work with VMRC (Holzer - 2 actual, 2 anticipated). 2013 - Parker - 17 actual, 5 anticipated (Loans for increased/more efficient production awarded through MARBIDCO Shellfish Loan Programs) Webster - 80 actual, 75 anticipated (Number of oyster leases placed in operation and planted with habitat-forming seed oysters to enable marine fauna to establish) Holzer - 2 actual, 3 anticipated (In 2013, work done with MDNR (as Fisheries Economist) and ASMFC (as Maryland representative in the Committee on Economics and Social Sciences). In 2014, will also work with VMRC and/or NOAA directly.)</p>
Number of seafood businesses (harvesters, aquaculturists, processors and recreational fishermen) whom adopt and implement responsible harvesting and processing techniques and practices.	3	1,023	<p>2011 - Includes new leaseholders provided individual and group assistance from SG Educational Programs number of growers producing seed from the RST systems and those obtaining financing provided assistance through SGEP faculty. 2010 work also included HACCP training. 2012 - Approximate number based on presentation given at the 2013 Maryland Waterman's Commercial Fishing and Aquaculture Expo and</p>

			<p>Tradeshaw (Parker - 4 actual, 4 anticipated). Remote Setting Training to date: 2011 had 20 sets completed using 218 million larvae, est 32 million seed, avg setting 15% 2012 had 113 sets completed (+465%), 567 million larvae (+160%), est 211 million seed (+560%) avg setting 37.23% (+148%) (Webster - 32 actual, 50 anticipated). Includes Maryland seafood processors who participated in the Maryland Crabmeat Quality Assurance Program and companies that have demonstrated product and/or process improvements in their operations as a result of Maryland Sea Grant assistance (Rippen - 19 actual, 19 anticipated). 2013 - Parker - 17 actual, 5 anticipated (Loans for increased/more efficient production awarded through MARBIDCO Shellfish Loan Programs) Webster - 50 actual, 50 anticipated (Remote setting expansion from five locations and nine tanks to nine locations with thirty tanks for production of spat on shell for planting expading number of aquaculture leases) Holzer - 756 actual, 104 anticipated (Transition of most striped bass fishermen to an Individual Transferable Quota (ITQ) system. In 2014, expectation that the remaining watermen, currently in the common pool, to transition to the ITQ as well.)</p>
<p>Number of tools, or guidelines derived from research to improve seafood production, seafood product quality, processing, handling, and safe consumption.</p>	2	18	<p>2010 - We have supported development of new tools to improve shelf life of seafood products. 2011 - We have worked to improve new seafood products, particularly seafood soup. 2012 - Instruction booklet and excel spreadsheet currently in press for the bottom culture of spat on shell oysters in Maryland (Parker - 1 actual, 1 anticipated). Publications developed and distributed: Production Systems, Remote Setting Systems, and Aquaculture Resource Guide (Webster - 3 actual, 3 anticipated). We have helped processors to improve new seafood products, including pasteurized shrimp, jonah crab, lobster and seafood soups. Also a developed a curriculum for the U.S. tuna industry and a self-audit spreadsheet tool. (Rippen - 5 actual, 5 anticipated). 2013 - Webster - 4 actual, 4 anticipated (Publications developed and distributed revision of popular titles and initiation of new training materials DIS-3 - 1 actual (Molecular PCR assay for RLV detection refined by the Schott lab to detect as few as 10 viruses)</p>
<p>Proportion of research studies funded that inform decision-making related to safe and sustainable seafood.</p>	5	45	<p>2010 - Numbers reflect percentages 2011 - Support research in oyster and blue crab restoration.25% - 2 of 8 total research studies funded. [2010] - 5% 2012 - Note this is a percentage of total research funding for 2012. 2012 funded projects include R/DIS-3, R/FISH-101, R/FISH-102. These projects relate to oyster setting (in situ restoration), striped bass reference points, and blue crab virus which overlap with research topics under other focus areas (hence a higher proportion that predicted). 2013 - Note this is a percentage of total research funding for 2013. 2013 funded projects include R/DIS-3, R/FISH-101, R/FISH-102. These projects relate to oyster setting (in situ restoration), striped bass reference points, and blue crab virus which overlap with research topics under other focus</p>

			areas (hence a higher proportion that predicted).
Reduction of commercial crab licenses derived from research to improve seafood production, seafood product quality, processing, handling, and safe consumption.	1,200	1,059	2011 - 100 Tidal Fish Licenses removed in 2011. [2010] - Revised: MD DNR retired 683 Limited Crab Catcher licenses in 2010. Total cost of all licenses removed \$2.25M. Total number = 783. 2012 - The number of licenses bought back was slightly smaller than we anticipated. The program has ended, and thus we do not expect to acquire more licenses in 2013 (Holzer - 15 actual, 0 anticipated). 2013 - Webster - 20 actual, 20 anticipated (Harvesters moving from crab harvesting to shellfish aquaculture through program activities) In 2012, DNR concluded its crab license buy back program, which ended our direct commitment to that effort.

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Program Objectives (2010 - 2013)

Program Objective	Achieved (yes/no)	Program Comments
2-3 Stakeholder groups (i.e., anglers, bait distributors) adopt responsible bait management practices	No	2010 - This is an objective to support our strategic plan under: Strategy 2.1b- Determine how restoration efforts affect or are affected by changes in coastal and estuarine conditions (e.g. temperature, salinity, wind, wave, nutrients, sediments, contaminants, climate change). For example, we hope through our live bait vector study to inform the public and bait distributors in the best management of bait to minimize the introduction of aquatic invasive species. 2011 - We have engaged in significant outreach with the angler and bait distributor communities through our live bait vector study (impact ID 15139). 2012 - We have engaged in significant outreach with the angler and bait distributor communities through our live bait vector study (impact ID 17065). 2013 - We have engaged in significant outreach with the angler and bait distributor communities through our live bait vector study (Impact ID 18448). In 2013, blood worm dealers in Maine, the major source for blood worms in the world of techniques to improve their bait packaging practices, but these have not been adopted. Ongoing work with extension agents will inform bait users of eco-friendly disposal techniques.
By 2012 Maryland Sea Grant affects how oyster restoration will be done and produces millions-billion of oyster spat for restoration and aquaculture purposes.	Yes	2010 - This is an objective to support our strategic plan under: Strategy 2.3a- Support the development and appropriate use of aquaculture for restoration and/or commercial enterprise. MD Sea Grant extension agents support hatchery operations for oyster spat and works with stakeholders to develop a viable oyster aquaculture facilities in MD. 2011 - Consistent with 2010, Maryland Sea Grant continues to work with state and local officials and potential oyster growers to ease leasing regulations, provide expert advice, and raw materials (i.e. oyster spat) to boost the developing oyster industry in Maryland. Number of oyster growers continues to increase. Oyster research activities are covered by impact IDs 15076 and 15061. Further oyster outreach and extension activities are covered in PRP for Sustainable Coastal Development (see impact IDs 14828, 14829, 15678). 2012 - Consistent with 2011, Maryland Sea Grant continues to work with state and local officials and potential oyster growers to ease leasing regulations, provide expert advice, and raw materials (i.e. oyster spat) to boost the developing oyster industry in Maryland. Number of oyster growers continues to

		<p>increase. Oyster research activities are covered by impacts 16971, 16979 and 16980.</p> <p>2013 - Maryland Sea Grant continues to work with state and local officials and potential oyster growers to ease leasing regulations, provide expert advice, and raw materials (i.e. oyster spat) to boost the developing oyster industry in Maryland. Number of oyster growers continues to increase. Oyster activities are covered by impacts 18359, 18361, and 18362.</p>
By 2012 Maryland Sea Grant funded research will have impacted the development of one new SAV restoration technology	Yes	<p>2010 - This is an objective to support our strategic plan under: Strategy 1.2d- Develop indicators of restoration success and/or failure. For example, MD Sea Grant supported research to develop a clonal repository of multiple species of SAV. The repository of the genotypes can be used by managers to select genotypes that will be the most successful in specific conditions.</p> <p>2011 - Specific research included SAV genotype responses to salinity changes (impact 15738) and SAV bed responses to climate variability (impact 14247) in the PRP on Healthy Coastal Ecosystems.</p> <p>2012 - Consistent with 2011 comment.</p> <p>2013 - Specific research included SAV genotype responses to salinity changes (impact 15738) and SAV bed responses to climate variability (impact 14247) in 2011. Current SAV research is contributing to our understanding of Susquehanna Flats recovery (R/SV-1).</p>
By 2012, develop ecosystem indices points for striped bass and menhaden relative to habitat and stock for use by fisheries managers.	No	<p>2010 - This is an objective to support our strategic plan under: Strategy 2.2a- Support the scientific foundation for, and the regional structures and processes needed to advance ecosystem-based fisheries management. The EBFM effort in Chesapeake Bay is in process and has yet to develop these indices.</p> <p>2011 - The EBFM effort in Chesapeake Bay is currently on hiatus as regional, state and federal managers consider EBFM strategies (impact ID 15743). Research continues on these issues through research grants and program development funds (impact IDs 14313, 15065, 15230). As we continue to progress towards developing reference points and management recommendations regarding these species we anticipate reaching this objective by the end of 2013.</p> <p>2012 - The EBFM effort in Chesapeake Bay is currently on hiatus as regional, state and federal managers consider EBFM strategies (impact ID 15743). Research continues on these issues through research grants and program development funds (R/FISH/EC103 104 Rp/FISH256).</p> <p>2013 - During 2013 PIs from two research grants (R/FISH/EC103 104) presented their final reports to the Chesapeake Bay Sustainable Fisheries Goal Implementation Team about coupled ecosystem-economic models for multispecies fishery management (18441). Research continues on striped bass ecosystem reference points (Rp/FISH256). Additional funding from other sources and new 2014 MDSG funding for menhaden research will improve understanding of menhaden stocks.</p>
By 2012, Maryland Sea Grants engages and organizes multisectoral stakeholders in EBFM process.	Yes	<p>2010 - This is an objective to support our strategic plan under: Strategy 2.2a- Support the scientific foundation for, and the regional structures and processes needed to advance ecosystem-based fisheries management. Though reference points are yet to be developed a highly successful effort to develop an EBFM policy for the Chesapeake Bay continues on target.</p> <p>2011 - Maryland Sea Grant has substantially engaged multiple sectors over the last four years on these issues and has been successful in developing management plans for 5 Chesapeake Bay species. The EBFM effort in</p>

		<p>Chesapeake Bay is currently on hiatus as regional, state and federal managers consider EBFM management plans and discuss possible management strategies (impact ID 15743).</p> <p>2012 - Consistent with 2011 comment.</p> <p>2013 - Maryland Sea Grant has substantially engaged multiple sectors from 2008-2011 on these issues and has been successful in developing management plans for 5 Chesapeake Bay species. Additionally, during 2013 PIs from two research grants (R/FISH/EC103 104) presented their final reports to the Chesapeake Bay Sustainable Fisheries Goal Implementation Team about coupled ecosystem-economic models for multispecies fishery management (18358). The EBFM effort in Chesapeake Bay is progressing slowly as regional, state and federal managers consider EBFM management plans and discuss possible management strategies.</p>
<p>By 2013 will enhance 2 information portals for seafood safety and ecosystem based fisheries management.</p>	<p>Yes</p>	<p>2010 - This an objective to support our strategic plan under: Strategies 2.2a and 3.3a- Support the scientific foundation for, and the regional structures and processes needed to advance ecosystem-based fisheries management. Support sustainable fisheries-dependent and seafood processing technologies.</p> <p>2011 - Consistent with 2010 comment</p> <p>2012 - Numerous portals and electronic tools have been developed to support sustainable fisheries including a website dedicated to aquaculture development and electronic media for training programs (seafood regulatory programs [HAACP], good aquaculture practices, a tuna industry-specific program).</p> <p>2013 - During 2013, an additional four information portals and tools were produced, including new seafood safety and seafood technology portals on the MDSG website and new photo, video, and Facebook integration on Maryland aquaculture website.</p>
<p>By 2013, 5% of research projects will be directed to safe and sustainable seafood</p>	<p>Yes</p>	<p>2010 - This is an objective to support our strategic plan under: Strategy 3.3a- Support sustainable fisheries-dependent and seafood processing technologies.</p> <p>2011 - We are on target to achieve this goal. In 2011, 2 of 8 newly funded research projects targeted this research area (oyster and blue crab restoration).</p> <p>2012 - We are well on target to meet this goal. In 2012, our research budget and program development supported numerous new and continuing projects under this topic including R/DIS-3, R/FISH-101, and R/FISH-102.</p> <p>2013 - We have met this target. Our research budget and program development supported numerous new and continuing projects under this topic including R/DIS-3, R/FISH-101, R/FISH-102, Rp/EN-266. These projects relate to oyster setting (in situ restoration), striped bass reference points, and blue crab virus which overlap with research topics under other focus areas (hence a higher proportion than predicted). For more information, see impact ID 18439.</p>
<p>By 2013, Crabmeat processors will use advanced packaging and crabmeat processing techniques that allow greater value to be obtained from lower grades of crabmeat.</p>	<p>Yes</p>	<p>2010 - This is an objective to support our strategic plan under: Strategy 3.3a- Support sustainable fisheries-dependent and seafood processing technologies. Our extension agent Tom Rippen working closely with industry is moving successful towards developing this product.</p> <p>2011 - MDSG extension has made significant advances in this area including training programs reaching hundreds of individuals around the world (impact ID 15787) and advancing freezing techniques that are improving the shelf life of crab meat (impact ID 14248 in Sustainable Coastal Development).</p> <p>2012 - MDSG extension continues to make advances in</p>

		<p>new seafood products and technology, including pasteurized shrimp, jonah crab, lobster and seafood soups.</p> <p>2013 - MDSG extension continues to make advances in new seafood products and technology and continues the Crabmeat Quality Control Program (18367).</p>
By 2013, develop ecosystem indices for disease and climate affects on striped bass for use by fisheries managers.	No	<p>2010 - This is an objective to support our strategic plan under: Strategy 2.1b- Develop understanding of targets for and roadblocks to sustaining natural resources (e.g., effects of climate, diseases, contaminants on harvestable fish species and essential habitat). Research supported in this area is limited.</p> <p>2011 - Research on striped bass is using traditional fisheries techniques and chemical and molecular studies to assess the striped bass recovery (impact IDs 14323, 15073). Additional work on disease and climate effects is currently limited.</p> <p>2012 - Consistent with 2011 comment.</p> <p>2013 - Research is ongoing for developing striped bass reference points (R/FISH-101 Rp/FISH-256). Additional work on disease impacts is currently limited.</p>
By 2013, the number of licensed commercial crab fishermen in Maryland will be reduced by 1200 in order to better match the available level of fishing effort to the resource capacity.	Yes	<p>2010 - Total buy back was approximately 900 when DNR and VMRC funds were exhausted. Buy back was deemed a success.</p> <p>2011 - Total buy back was approximately 900 when DNR and VMRC funds were exhausted. Buy back was deemed a success (Impact IDs 15693, 15780).</p> <p>2012 - The buy back program ceased in 2012 and was deemed a success. 25 additional licenses were bought back in 2012.</p> <p>2013 - The buy back program ceased in 2012 and was deemed a success.</p>
By 2014, develop quantitative reference points for disease and climate affects on striped bass for use by fisheries managers.	No	<p>2010 - This is an objective to support our strategic plan under: Strategy 2.1b- Develop understanding of targets for and roadblocks to sustaining natural resources (e.g., effects of climate, diseases, contaminants on harvestable fish species and essential habitat). EBFM management decisions on striped bass remain in discussion and may extend the accomplishment of this objective.</p> <p>2011 - Research on striped bass is using traditional fisheries techniques and chemical and molecular studies to assess the striped bass recovery (impact IDs 14323, 15073). Additional work on disease and climate effects is currently limited. The EBFM effort in Chesapeake Bay is currently on hiatus as regional, state and federal managers consider EBFM strategies. However, some work on quantitative reference points continues below these management levels.</p> <p>2012 - Consistent with 2011 comment. See impact 16977.</p> <p>2013 - Research is ongoing for developing striped bass reference points (R/FISH-101 Rp/FISH-256). See also Impact ID 16977. Additional work on disease impacts is currently limited.</p>
By 2014, regional EBFM structure, facilitated by Maryland Sea Grant, develops ecosystem indices and reference points for five key species that inform ecosystem-based management efforts, that in part, address sustainable seafood supplies.	No	<p>2010 - This is an objective to support our strategic plan under: Strategy 2.2a-Support the scientific foundation for, and the regional structures and processes needed to advance ecosystem-based fisheries management. The EBFM effort in Chesapeake Bay is in process and has yet to develop these indices but expects to within several years.</p> <p>2011 - Briefs for 5 species and a monograph were distributed among EBFM partners. The EBFM effort in Chesapeake Bay has since gone on hiatus as regional, state and federal managers consider EBFM strategies. However, some work on quantitative reference points</p>

	<p>continues below these management levels. See impact IDs 15743 and 15230.</p> <p>2012 - Consistent with 2011 comment.</p> <p>2013 - Maryland Sea Grant has substantially engaged multiple sectors from 2008-2011 on these issues and has been successful in developing management plans for 5 Chesapeake Bay species. Additionally, during 2013 PIs from two research grants (R/FISH/EC103 104) presented their final reports to the Chesapeake Bay Sustainable Fisheries Goal Implementation Team about coupled ecosystem-economic models for multispecies fishery management (18358). The EBFM effort in Chesapeake Bay is progressing slowly as regional, state and federal managers consider EBFM management plans and discuss possible management strategies.</p>
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